

FIREMAN BOILER OPERATOR SYLLABUS

GENERAL INFORMATION:

This Syllabus has been approved by the Technical Safety Authority of Saskatchewan and is intended to assist candidates studying for the Fireman's examination.

A. Recommended Exam Preparation:

It is strongly advised that a candidate should:

1. Become familiar with the operation of boilers and boiler systems.
2. Complete an approved Fireman's course offered by various educational institutions in Saskatchewan either in-person or on-line OR follow a rigorous program of self-study. The "*Limited Power Engineer's (fireman) Handbook*" published by PanGlobal Training Systems Ltd. is one course which provides information pertaining to the examination syllabus¹.
3. Obtain copies of *The Boiler and Pressure Vessel Act and Regulations* for Saskatchewan either from the Queen's Printer or downloaded free of charge from the internet.

B. Application for the Examination:

The application must be received at least five (5) business days prior to the date of the exam. A non-refundable/non-transferable examination fee is required.

The applications are available on the TSASK website at:
<http://www.tsask.ca/power-engineering/exam-calendar>

Please note that TSASK is only accepting Visa or Mastercard payments online at this time. If candidates are not able to pay by credit card, they may pay in person or mail in their application with the appropriate payment attached to one of the TSASK offices listed:

Examination & Certification
2202 2nd Ave
REGINA, SK S4R 1K3

Examination & Certification
2213 - 11th St W
SASATOON, SK S7M 1J4

TSASK accepts cash or cheque, Visa, Mastercard or debit.

¹This course is endorsed by TSASK. Please contact TSASK at 1-866-530-8599 if you feel you have a suitable course of study.

C. Examination Instructions:

The examination:

- Consists of one (1) examination paper with 100 multiple-choice questions.
- Duration is two (2) hours.
- Passing grade is 65%.

A candidate failing to obtain a passing grade will be required to wait thirty (30) days before they are eligible to reapply for examination. Please refer to, “*Examination Rewrite Policy for Power Engineering Exams*”, found on the TSASK website at www.tsask.ca.

D. Examination Materials:

A candidate is allowed to use and may be provided, the following items in the examination room. The candidate should bring his/her own copy of The *Boiler and Pressure Vessel Act and Regulations* as there will be limited copies available.

- A non-technical English language dictionary
- *The Boiler and Pressure Vessel Act* (latest version)
- *The Boiler and Pressure Vessel Regulations* (latest version)
- The approved formula sheet provided as part of this syllabus
- A non-programmable calculator.

E. Examination Notes:

The candidates shall:

- Be prepared to provide picture ID to the Examiner prior to the examination.
- Have **NO** cell phones or any other electronic communication devices with them in the examination room.
- Show all examination materials listed in Part D of this syllabus to the examiner for approval.
Note: Pages may be tabbed and information highlighted **BUT** no additional information may be written into the material.
- Have **NO** other reference materials except those listed in Part D of this syllabus in the examination room.

EXAMINATION DETAILS:

Questions on the following topics will be on the examination. The percentage provided with each topic is an indication of the number of questions on the exam dedicated to the specific topic.

A. *The Boiler and Pressure Vessel Act, Regulations* and Reference Codes: 5%

1. Know the purpose and scope of *The Boiler & Pressure Vessel Act & Regulations* with respect to the following:
 - a) Regulations governing the operation of boilers & pressure equipment.
 - b) Regulations pertaining to operator qualifications.
 - c) Operator staffing requirements for high and low pressure boilers.
 - d) Duties of an operator or owner.
 - e) Definitions
2. Have an awareness of the purpose and information in the CSA and ASME Codes.

B. Basic Principles of Thermodynamics: 3%

1. An introduction to Thermodynamics.
 - a) Be able to convert between Fahrenheit and Celsius temperatures.
 - b) Understand heat characteristics and the methods that heat is transmitted (radiation, conduction and convection).
 - c) Define sensible and latent heat.
 - d) Understand the properties of steam and water with regards to the boiling point and expansive properties of steam.
2. Know the various methods of temperature measurement and types of thermometers used in industry.

C. Boiler Types, Design and Terminology: 10%

1. Demonstrate knowledge of boiler terminology.
 - a) Know the difference between high and low pressure boilers.
 - b) Become familiar with various boiler components: shells, drums, watertubes, firetubes, tubesheets.
 - c) Describe the types of stays used in firetube boilers.
 - d) Describe handhole, manhole and drum connections.
2. Describe the applications, construction, operation, advantages and disadvantages of the types of boilers used in industrial and heating plants:
 - a) Watertube, copper-tubular, finned-tube, and packaged.
 - b) Cast iron sectional.
 - c) Firetube: horizontal, vertical and packaged.
 - d) Electric: electrode and immersion types.

D. Boiler Fittings for Steam and Hot Water Boilers: 10%

1. Steam boiler fittings: Name, identify and explain the purpose and operation of fittings required for low pressure and low capacity high pressure steam boilers.
 - a) Pressure gauges and siphons.
 - b) Safety and relief valve testing, mounting and blow-down adjustment.
 - c) Gauge glasses and valves, water columns and testing.
 - d) Check valves, vent valves and pressure reducing stations.
 - e) Describe the purpose of blow-down tanks, valves and blow-down procedures.
 - f) Know the differences between low pressure and high pressure steam boiler fittings.
2. Hot water heating boiler and system fittings: Name, identify and explain the purpose and operation of fittings required for hot water boilers.
 - a) Pressure or altitude gauges, combination gauges, aquastats.
 - b) Thermometers, safety relief valves, temperature relief devices.
 - c) Stop valves, auto fill valves, and drain or blow-off valves.
 - d) Describe hot water system components including: circulating pumps, expansion tanks, steam to hot water converters, balancing valves, flow control valves, air vents and separators, diverters and pressure reducing valves

E. Automatic Boiler Controls: 10%

1. Discuss the operation, testing and maintenance of low-water fuel cutoffs.
 - a) Float and electrode low-water level fuel cutoffs.
 - b) Low water causes.
2. Describe steam heating boiler feedwater controls.
 - a) Feedwater float switch operating a low-water fuel cutoff and a pump.
 - b) Boiler feedwater and condensate piping connections.
 - c) A Hartford loop system.
3. Name and describe the various operating controls on heating boilers.
 - a) On-off, high-low fire, modulating and high limit control.
 - b) Safety switches on fuel supplies, high and low gas cut-offs.
 - c) Explain the testing and maintenance of heating boiler controls.
4. Explain the design and operation of combustion controls on heating boilers.
 - a) Thermocouples, flame rods, photo-electric cells, flame scanners.
 - b) Testing of flame failure devices

F. Fuels and Combustion: 5%

1. Discuss the principles of combustion, common fuels, draft methods and flue gas analysis with respect to:
 - a) Natural and mechanical draft arrangements and control.
 - b) Draft measurement using U-tube and inclined draft gauges.
 - c) Common boiler fuels.
 - d) Requirements and reactions for complete and incomplete combustion.
 - e) Flue gas analysis and how the results are applied.
2. Describe the operation of various gas and oil burners.
 - a) Atmospheric, combination, refractory and ring gas burners.
 - b) Pilot light types.
3. Describe the operating principles of oil burning systems.
 - a) Burner types, fuel storage, atomization, electric ignition and filters.
 - b) Construction and operation of automatic gas valves such as diaphragm, solenoid and motorized valves.
 - c) Components and operation of a fuel oil system.

G. Boiler Operation and Maintenance: 10%

1. Describe the operation of steam and hot water boilers.
 - a) Explain the preparation required before starting up a boiler.
 - b) Explain the procedure for starting up and shutting down a boiler.
 - c) Explain the precautions necessary to prevent uneven expansion and thermal shock.
 - d) Describe how to cut in an additional boiler.

2. Describe routine and emergency boiler operation.
 - a) Know the purpose of operating logs and describe daily and monthly boiler checks.
 - b) Describe routine operations including blow-down procedures and proper responses to flame failures, high steam pressure, low and high water levels.
 - c) Describe operator responses to emergency conditions.
 - d) Explain furnace and pressure explosions, their causes and prevention.
 - e) Describe the reasons for boiler accidents.
 - f) Explain good operator traits, practices and due diligence.
3. Describe routine maintenance and inspection for boilers.
 - a) Explain the mechanical and chemical methods used for fireside and waterside cleaning.
 - b) Describe internal and external boiler inspections.
 - c) Describe a hydrostatic test.
 - d) Explain wet and dry boiler layups.
 - e) Know the symptoms of a leaking firetube.
 - f) Describe the methods used to detect cracks in boilers.

H. Boiler Water Treatment: 8%

1. Explain the reasons for water treatment.
 - a) Describe the classes of impurities found in ground and surface water and explain the problems they cause.
2. Describe common external feedwater treatment methods.
 - a) Describe various types of water filters.
 - b) Explain the purpose and operation of sodium zeolite water softeners and the procedure for regenerating them.
 - c) Describe troubleshooting for sodium zeolite softeners to determine operating problems.
3. Describe internal boiler water treatment.
 - a) Describe internal treatment for the prevention of scale, corrosion, caustic embrittlement, foaming and return line corrosion.
 - b) Explain chemical deaeration, sludge conditioning and pH control.
 - c) Describe chemical feed systems.
 - d) Describe the types of boiler blow-down and their purpose in water treatment programs.
4. Describe common water tests for steam boilers.
 - a) Describe a safe method for obtaining a boiler water sample for testing.
 - b) Explain common boiler water testing methods, terminology and equipment.
 - c) Describe tests for measuring hardness, total dissolved solids, alkalinity, sodium sulphite, phosphate and pH.
 - d) Explain how the test results are interpreted.

I. Pumps and Air Compressors: 8%

1. Describe the various types of pumps used in buildings and plants.
 - a) Define the common terms associated with pump performance.
 - b) List the common applications of pumps
 - c) Describe reciprocating, centrifugal, rotary and turbine pumps and their components.

2. Describe pump operation and maintenance procedures.
 - a) Describe the construction and function of wearing rings.
 - b) Describe shaft sealing and the procedure for replacing compression type pump packing.
 - c) Describe the types of mechanical seals.
 - d) Describe bearings, flexible couplings and shaft alignment procedures.
 - e) Describe pump start-up, priming procedures and cavitation.
 - f) Describe normal operation and trouble shooting for pumps.
3. Describe the operating principles of air compressors.
 - a) Describe the main classifications and types of air compressors
 - b) Describe air compressor auxiliary equipment such as intercoolers, aftercoolers, receivers, and air dryers.
 - c) Discuss installation, operating controls and preventive maintenance.

J. Valves, Piping Materials, Expansion, Support, Insulation and Steam Traps: 8%

1. Discuss the design, application and maintenance of common types of valves.
 - a) Describe gate, globe, butterfly, ball and plug valves.
 - b) Describe the use and operation of check and non-return valves.
 - c) Discuss the function of a pressure reducing valve and where it is used in a high pressure steam plant.
 - d) Describe valve identification markings.
 - e) Describe typical valve maintenance.
2. Describe piping materials, size classification and methods of pipe connection.
 - a) Explain the applications of the different materials used in the manufacture of piping and fittings.
 - b) Explain pipe size schedules and classifications.
 - c) Identify screwed, flanged and welded pipe connections.
3. Discuss piping expansion, support and insulation.
 - a) Explain pipe expansion and the use of expansion bends and joints.
 - b) Explain the purpose of pipe supports and designs.
 - c) Explain the purpose of pipe insulation and common insulation materials.
4. Explain the purpose, installation and types of steam traps.
 - a) Explain the function of a steam trap.
 - b) Describe mechanical and thermostatic steam traps.
 - c) Describe the piping arrangement for a steam trap.
 - d) Explain the purpose of a strainer.
 - e) Explain the causes, effects and prevention of water hammer.

K. Steam & Hot Water Heating Systems Arrangements and Components: 8%

1. Describe the operation and maintenance of steam heating equipment and components.
 - a) Describe the operation of a steam heating system.
 - b) List and describe the auxiliary equipment used in a system including radiators, steam traps, convectors, unit heaters, ventilators, air vents, condensate and vacuum pumps.
 - c) Describe the types of piping and equipment layout for steam heating systems.

2. Describe the operation of hot water systems.
 - a) Describe gravity, loop, one pipe, two pipe direct and reverse, and multiple zone systems.
 - b) Describe hot water system components including: circulating pumps, expansion tanks, steam to hot water converters, balancing valves, flow control valves, air vents and separators, diverters and pressure reducing valves.
 - c) Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
 - d) Explain the use of antifreeze in hot water systems.
 - e) Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe and explain the function of the components of an electric control circuit including:
 - a) Thermostats, three way valves, humidity controllers and pressure controllers.
 - b) Describe the controlled devices in electrical control systems.

L. Building Services: Water Supply Systems, Sanitary Drainage Systems, Humidification, Ventilation and Air Filtration: 5%

1. Explain the various water supply systems in a building.
 - a) Cold water distribution, pneumatic tank system.
 - b) Hot water distribution system.
 - c) Direct and indirect hot water heaters.
 - d) Temperature regulation, backflow and protection devices.
2. Describe various sanitary drainage systems employed with buildings.
 - a) Describe the overall layout of building drainage systems.
 - b) Describe storm water drainage systems for buildings.
 - c) List routine maintenance of sanitary drainage system devices.
3. Describe humidification.
 - a) Explain the equipment and principles of humidification.
 - b) Describe the types of humidifiers.
 - c) Describe air washers and humidifier controls.
4. Describe the various ventilation systems and air filters found in buildings.
 - a) Explain the difference between natural and mechanical ventilation.
 - b) Describe the types of contaminants found in air.
 - c) Describe the types of air cleaning devices used in buildings.

M. Fire and Building Safety: 5%

1. Discuss methods of extinguishing various classifications of fires and describe fire extinguishers and fire detection systems.
 - a) Explain the need for and intent of fire protection standards, laws and regulations.
 - b) Explain the different fire classifications and the extinguishing methods for each.
 - c) Explain the application and operation of standpipes, hoses and sprinklers in buildings.
 - d) Explain the various types of fire and smoke detectors.
 - e) Describe the operation, placement and maintenance of the common types of portable fire extinguishers.
 - f) Discuss the need and use of a fire pump.

2. Describe how the building operator can prevent accidental situations to protect the occupants of their facility.
 - a) Explain the personal safety responsibilities and precautions that must be applied by the Building Operator.
 - b) Describe the general safety precautions required for the maintenance and operation of buildings.
 - c) Explain electrical safety and the prevention of electric shock.
 - d) Identify common scenarios where the Building Operator can prevent accidents and explain the importance of First Aid and CPR training.

N. Electricity, Lighting Systems and Equipment: 5%

1. Discuss the design and accessories of an electrical circuit.
 - a) Explain electricity, electric circuits and voltage drop.
 - b) Calculate basic current and power in an electric circuit: volts, amps, watts, and kilowatt-hours.
 - c) Estimate the cost of electrical power for a facility.
 - d) Describe switches, fuses, circuit breakers, and receptacles.
 - e) Explain electric shock.
2. Describe the design and troubleshooting of lighting systems and electric motors.
 - a) Explain what is meant by a good lighting system and its maintenance.
 - b) Describe problems such as short circuits, grounds and bad connections.
 - c) Describe static electricity.
 - d) Describe transformers and electric motors.
3. Explain the different lighting systems and the basic design methods for lighting a space.
 - a) Describe the common types of lighting equipment.
 - b) Explain the various methods of lighting control.
 - c) Describe the general requirements for emergency lighting in buildings.
 - d) Discuss how lighting, air conditioning and energy conservation are considered in buildings.

FORMULA/INFORMATION SHEET

The new formula sheet is included on the next page for the candidates use during the exam. Under no circumstances shall the Formula sheet have any additional markings. If writing or markings are on the Formula Sheet, the candidate shall not be allowed to use the Formula Sheet in the exam.

FORMULA/INFORMATION SHEET

NOTE: This information is allowed for use in the exam to assist the candidate with some questions which may appear on the examination. Some formulas may have to be transposed or changed to solve for the unknown.

THERMODYNAMICS:

$$^{\circ}\text{F} = 9/5^{\circ}\text{C} + 32 \text{ or } 1.8^{\circ}\text{C} + 32$$

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32) \text{ or } 0.56 (^{\circ}\text{F} - 32)$$

$$\text{K} = 5/9 \times ^{\circ}\text{R} \text{ or } 0.56 \times ^{\circ}\text{R}$$

Latent Heat of Evaporation for water = 2257 kJ/kg. Therefore, it takes this amount of heat to change a unit mass of a substance (water) from liquid to vapour (steam) without changing its temperature.

ELECTRICITY:

$$1 \text{ watt} = 1 \text{ volt} \times 1 \text{ ampere}$$

$$\text{Power} = \text{volts} \times \text{amperes}$$

$$\text{Transposing: amperes} = \text{power} / \text{volts} \text{ OR } \text{volts} = \text{Power} / \text{amperes}$$

*The candidate should be able to transpose (change the formula) to solve for the unknown for higher level Power Engineering examinations.

Power is expressed in watts or kW (kilowatts). 1000 watts = 1 kilowatt

Energy = power x time i.e. the answer will be in kilowatt hours.

COMBUSTION:

Air is composed of 21% oxygen and 79% nitrogen by volume.

TSASK has approved this formula sheet for use in the Limited Power Engineer's (Fireman) Exam.

DO NOT MAKE ANY ADDITIONAL WRITINGS OR MARKS ON THIS SHEET OR CANDIDATES WILL NOT BE ALLOWED TO USE THE MARKUP DURING THE EXAMINATION.